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Life Cycle of Severe Storms

MORTON L. BARAD, Meteorology Laboratory, AFCRL

The most concentrated program yet undertaken to chart the life cycle and internal dynamics of severe storms was begun during May 1963 in southwest Oklahoma. This program was conducted jointly by the Air Force Cambridge Research Laboratories, the U. S. Weather Bureau, the Army, and the Navy. AFCRL, with 14 of its scientists, contractor personnel, and its specially instrumented aircraft for meteorological measurements played a major role in the program which ended June 7, 1963.

Known as the National Severe Storms Project, this program has been conducted annually for the past several years in the Oklahoma area. This year's effort was the most extensive in the series. The southwest corner of Oklahoma has proved to be an ideal location for these studies because of the frequency and magnitude of thunderstorm activity during the late spring.

Scientists measured all aspects of particular storms from their early formation as cumulus clouds, through their growth as anvil-top thunderheads (which sometimes measure 50 miles across) to their eventual dissipation. Measurements included the electrical activity associated with the storm, the internal vertical and cyclonic wind structure, moisture formation, and internal pressures. These measurements will be correlated with large-scale meteorological patterns in the southwest U. S. and with the more localized temperature-humidity conditions.

A specially instrumented C-130 was used to penetrate the clouds in the early stages of storm development and continued to make measurements at the edges of the storms as they

grew. An F-100 was used to make altitude penetrations through the center of the storms. Weather stations operated by the Air Force, the FAA, and the Weather Bureau tracked the storms simultaneously to continuously measure their structure. Electrical and photographic measurements from above the storms were taken by AFCRL's U-2 research aircraft. Special stereo photographs were also taken from ground level. These will be used for measuring vertical storm growth in detail. AFCRL was fortunate in that a major hail storm occurred during this project, with hail as large as baseballs.

Tinker AFB, Oklahoma, served as headquarters for the operation. Three AFCRL meteorological research groups--Weather Radar, Experimental Meteorology, and Cloud Physics--under the direction of Ralph Donaldson, Harold Klieforth, and Robert Cunningham respectively--participated in the program.

mining water on the moon

DR. JOHN W. SALISBURY, Space Physics Laboratory, AFCRL

Of the resources likely to be found on the moon, water is the most precious. Water more than any other resource would ease the logistical burden of a prolonged visit to the moon. If the moon is used as a staging area for interplanetary travel, water can provide the raw material for oxygen-hydrogen fuels needed to take the space vehicle to distant planets and back.

There is considerable evidence that water deposits can in fact be found on the moon. The evidence is sufficiently strong to warrant consideration of possible methods of mining, transporting and processing. Also to be considered are potential energy sources needed to extract the water from minerals and to dissociate water molecules into the hydrogen and oxygen needed for fuels.

For some time, an AFCRL group under Dr. John W. Salisbury has been considering both potential water deposits on the moon and mining techniques. People at NASA are also considering these matters, of course, and this mutual interest has led to the formation of a working group on extraterrestrial resources. The group is composed of personnel from the Air Force, Army, NASA, the Rand Corporation, and from various industries and universities. The mining and processing portion of this group is under the chairmanship of Dr. Salisbury. Three meetings of the mining and processing group have already been held, one in November 1962, another in February 1963, and a third at AFCRL on 18 June 1963. Following is a resume of a preliminary report covering discussions at the February 1963 meeting of the group.

Water may possibly be found in several types of deposits on the moon. It may persist as ice in permanently shadowed zones because of the low temperatures in the sheltered areas and the moon's low vapor pressure. Thus, relatively large surface deposits of ice may be present in crater bottoms near the lunar poles. Due to the unfavorable location, however, it is unlikely that these surface deposits could be effectively mined.

It is possible that layers of ice or hydrated minerals may exist in the upper few meters of the lunar surface materials. This type of deposit could be mined by open-pit methods. Similar ice or hydrated minerals may also be found at considerable depths, necessitating underground mining techniques. Still another source is bare, unenriched rock. Processing of water from this source would be extremely difficult--but it may well prove to be the only source available.

Among the general conclusions reached by the group on the basis of the February 1963 meeting were:

1) If lunar ore deposits cannot be processed in situ, underground mining and transport will probably be more feasible and economical than surface operations because of the importance of creating an acceptable environment for both men and machines.

2) If thin, surface, polar ice deposits are processed, a complex solar furnace using a batch process will probably be the most feasible and economical extraction system.

3) If shallow, nonpolar, blanket-type subsurface ice or hydrated mineral deposits are processed, an electric-arc furnace powered by a nuclear reactor may be the most feasible and economical system.

4) If thick surface or subsurface ice or massive hydrated mineral deposits are processed, it may be possible to develop a nuclear Frasch process to extract water in situ. This, or any other extraction technique that will eliminate the need for mining and transport, is greatly to be desired.

5) If bare rock is the only source of water available on the moon, the electric-arc furnace appears to be the most promising extraction system, except near the poles where sunlight is available a large portion of the time.

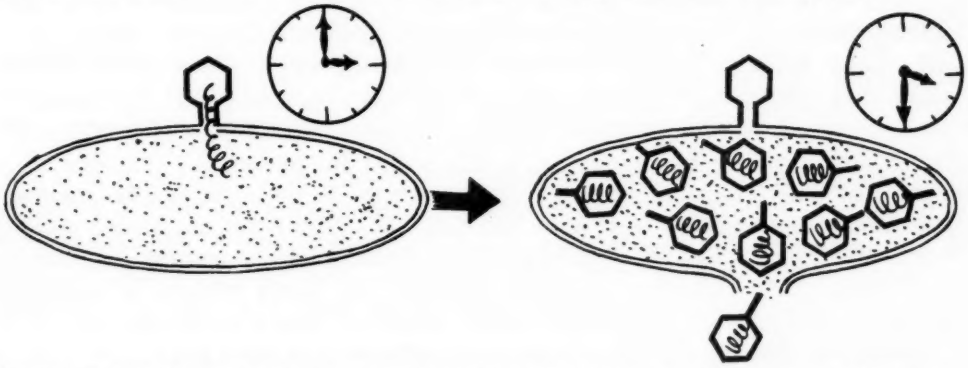
At the June 18, 1963 meeting of the group, areas of basic and applied research were defined which may lead to the effective mining and processing of lunar water deposits. It is clear that the alien environment of the moon will require a complete reevaluation of known mining and processing techniques, and probably the development of new ones.

bacteria get bitten, too

CAPT B. D. STOLLAR, Biological Sciences Division, AFOSR

Some of the most fundamental knowledge concerning cellular control mechanisms has come from studies of bacteria infected with submicroscopic "bacteriophage" viruses. Such model systems have shown the way to fruitful experiments with animal cells, and many of the basic principles of operation have been found to apply to both systems. Study of the infection of bacteria by viruses has shed light not only on our own human virus infections, but also on the very mechanisms which dictate how we are constituted as humans. It appears that the fundamental control principles are universal in the biological world of earth.

The most intensively studied bacterial viruses are known as the T-series of bacteriophages which infect the common intestinal bacterium, Escherichia coli. The virus particle consists simply of DNA (deoxyribonucleic acid, the polymer which carries hereditary information) surrounded by a protein coat. The protein coat forms a "head" structure and a tubular "tail." With this tail portion, the virus attaches to a susceptible host bacterium. The whole protein coat stays on the outside of the host cell, while the viral DNA is injected through the tubular tail into the bacterial cell. If one then looks for the virus, it seems to have vanished, and cannot be found inside or outside the host. Suddenly, thirty minutes later, the



bacterial cell explodes and up to 50 new virus particles are thrown into the growth medium ready to look for new hosts.

All that enters the bacterium is a piece of a definable chemical, DNA, corresponding to about 1% of the bacterium's own DNA in

quantity. Yet, as soon as it enters the host, the small amount of viral DNA takes over all the machinery of the cell. The bacterium stops growing immediately; the machinery for building its own constituents is turned off and converted for synthesis of equipment to build the virus components, and then for the synthesis of the virus components themselves. The virus even uses the bacterium's old scaffolding (ribosomes) on which to build viral protein. The new protein then coats the new viral DNA during a maturation phase, to complete the viruses, and the host cell ruptures. Within these thirty minutes, one can examine a vast array of mechanisms by which one molecule of DNA (molecular weight 125 million) takes over and redirects the whole operation of a living cell to a completely new pattern of biosynthetic production.

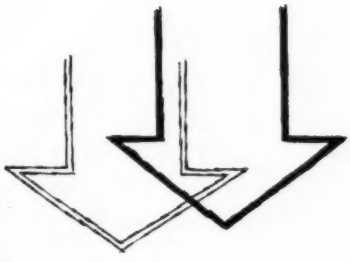
Many variations on the above theme have been discovered. All depend on the delicate balance of the relationship between the virus and the host. In some cases, indeed, rupture of the bacterium does not occur, but the viral DNA actually becomes incorporated into the bacterial DNA and stays with it for several generations. At a later time it may be induced by various means to again produce a new bacteriophage which does rupture the bacterium.

Many scientists have taken up the detailed study of these phenomena. Among them, R. Thomas of Brussels, an AFOSR grantee, has investigated aspects of the specificity that determines whether a virus can attach to a given strain of bacteria, and whether such an attachment will result in bacterial rupture or not. Dr. Thomas has studied a type of bacteriophage (lambda) whose DNA usually does become incorporated in the DNA of the host, Escherichia coli. Changes in a localized area in the viral DNA chain can cause this bacteriophage to rupture the host instead. Dr. Thomas has also described changes in the host-bacterial DNA which affects the outcome of the bacteriophage infection; in this case, a virus which normally causes rupture is unable to do so and its DNA takes up a harmless association with the host DNA without causing rupture. Thus, the principles of host-parasite relationships exists at a molecular level. Dr. Thomas has also studied the early stages of infection during which new proteins are built; some of these proteins are enzymes which are required for the synthesis of new DNA.

Studies of bacteriophage-bacteria interactions, in parallel with other investigations into bacteria, plants, and animals, have led to a level of understanding of genetic and control phenomena which was, ten years ago, unimaginable. Dr. C. P. Haskins, President of the

Carnegie Institution, has named this advance as one of three outstanding achievements of all science in the last decade. In comparison to such events as those leading to and including space exploration, and the new discoveries of radioastronomy, he concludes that "the third selected area of advance (that concerning genetic coding) may in some ways be the most profound of all, though far from the best known." He suggests that this advance has produced possibly the most thoroughly revolutionary new insights, even though it has involved a magnitude of human and material resources which, by comparison with the other examples, is "positively miniscule."

DOUBLE-PROBE MEASUREMENTS in a FLUCTUATING DISCHARGE



ALAN GARSCADDEN and RICHARD S. PALMER
Plasma Physics Research Laboratory, ARL

The positive column of a gas discharge in the rare gases, although visibly appearing homogeneous, is often found to contain moving striations when examined with rotating mirror and photomultiplier methods.

Many techniques have been used to obtain the electron energy distribution from current-voltage curves of a probing electrode, but difficulty is often experienced in the interpretation of results due to the presence of relatively large amplitude fluctuations in the column.

It has been noted that the moving striations can be identified with the presence of some of the fluctuations. Experiments have also shown that the "regular fluctuations" caused by the striations, and also the apparent "grass" recorded by probes located in the same azimuthal plane, are well correlated in certain discharges.

Taking advantage of this correlation, the use of a double-probe method to obtain the energy spectrum of the electrons has proved simple and effective. The energy spectrum can be found by analyzing the second derivative of the normal current-voltage curve. The double-probe geometry includes two identical probes placed in the same cross

section of a discharge tube and at the same radius within that cross section (Figure 1).

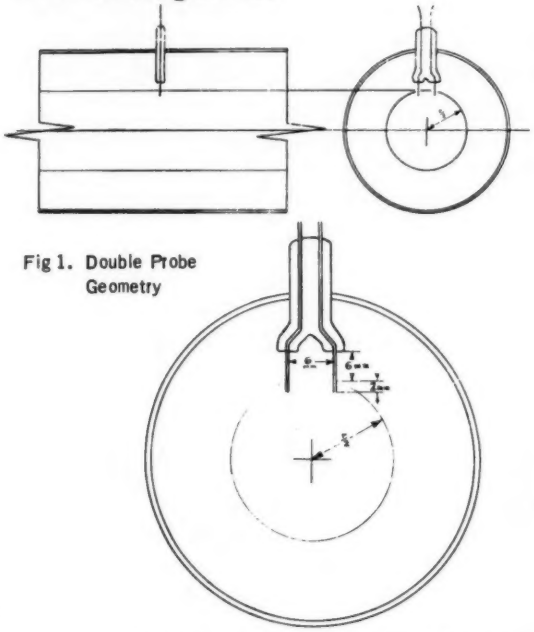


Fig 1. Double Probe Geometry

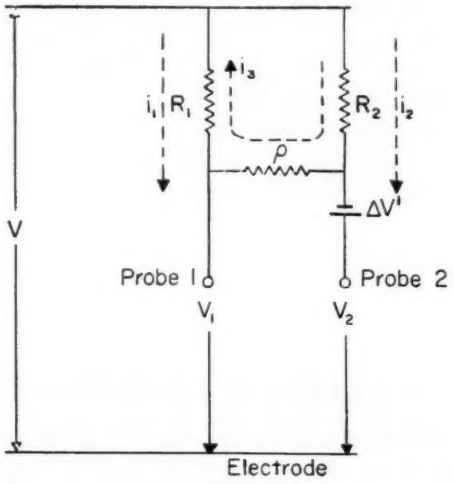


Fig 2. Circuit Arrangement

The circuit (Figure 2) is composed of balanced resistors $R_1 = R_2$ in each arm with one side containing an additional small voltage ΔV^1. To both probes there is applied a sweep voltage V with respect to an electrode of the discharge. A signal proportional to Δi (the current difference in the two arms caused by a small voltage difference ΔV Between the two probes) is measured across the resistance ρ.

In order to demonstrate the method, a double-probe system was installed in neon, helium and other inert gas-glow discharges. Measurements were made in discharges with voltages 60-100v, currents 50-100ma, and pressures from 60-500 microns Hg. The first derivative curves agree with those obtained by graphic differentiation or by use of a derivative circuit. The advantages of the present method are that the traces are obtained rapidly and the first derivative trace is relatively free from noise. Therefore, by using a sweep voltage V, linear with respect to time, it was possible to differentiate this signal using a conventional circuit, and to obtain the second derivative. The resulting trace $d^2 i/dV^2$ vs. V is proportional to $f(V)V^{-1/2}$ where f(V) is the function describing the electron energy.

A more detailed report is contained in ARL TR 63-50.

OBSERVATIONS of 20 JULY ECLIPSE

DR. JULES AARONS, Space Physics, Optical Physics, Upper Atmosphere Physics, and Terrestrial Sciences Laboratories, AFCRL

An extensive program of observations is planned during the solar eclipse of 20 July by AFCRL scientists. The concentrated attention given this particular eclipse by AFCRL is due largely to its proximity to AFCRL and its field sites. The path of totality crosses the Bangor, Maine area, a path which permits AFCRL the rare opportunity to make many observations from instruments presently in place.

Additional temporary field sites will be set up in the Bangor, Maine area. The over-all program calls for a variety of instrumentation and facilities, including AFCRL's 84- and 150-foot radiotelescopes in Hamilton, Mass., and an F-104 and KC-135 aircraft.

Special emphasis will be given to radio observations. Of primary interest will be the effects of the eclipse on the ionosphere. Other programs will be concerned with observations in the visible and infrared portions of the spectrum. These programs involve infrared measurements of the solar corona and chromosphere, airglow, sky brightness, and studies of the size and shape of the moon. Although activity will be concentrated in the Maine and Massachusetts areas, AFCRL and its contractors will undertake programs which extend across much of the path of the eclipse. This path of totality moves from Alaska, southeastward across Canada, to Maine.

The radio observations may furnish important clues to the dynamic process of the ionosphere. The ionosphere is largely a pro-

duct of the interaction of solar energy with air molecules in the earth's atmosphere. By observing ionospheric conditions before, during, and after the 90 seconds' eclipse period, it may be possible to derive some new insight into ionospheric processes.

Effects of the eclipse on the ionosphere will be measured by a variety of methods. The 150-foot radiotelescope at Hamilton, Mass., will be used to measure variations in the signal strength from the radio star Cassiopeia. This signal strength will vary with the changes in the ionosphere. Signals reflected from the moon and transmitted by the Army's Fort Monmouth, N. J., laboratories will be received by the 84-foot radiotelescope at Hamilton, Mass. From the analysis of the Faraday Rotation of these lunar-reflected signals, it will be possible to learn of any changes in the electron density of the earth's atmosphere caused by the eclipse.

From Fort Churchill, Canada, AFCRL will fire a Black Brant rocket with instrumentation for measuring variations in the D-and E-layers of the ionosphere during the eclipse.

Riometers will be used in several experiments. These instruments are designed to measure the relative ionospheric opacity. They do this by listening to the general cosmic background noise. If, during the brief 90 seconds' period of the eclipse, ionospheric density is reduced due to normal recombination of electrons and positive ions without the corresponding creation of these charged particles by the sun's action, this will be detected by the riometers. The riometers will operate over a broad band of frequencies.

To measure changes in the D-layer of the ionosphere, riometers located in Maine will receive Loran-C signals transmitted from a Coast Guard station in Nantucket. By noting changes in phase and amplitude of the signals, the changes in the height and reflectivity of the D-layer resulting from the eclipse can be measured. The effects of the D-layer will also be measured by an instrumented KC-135 aircraft. This aircraft will meet the eclipse over Fort Churchill, Canada. By following along the path of the eclipse, it may be possible to observe the total eclipse for as long as four minutes.

Other instrumentation will include ground-based cameras, and instrumentation for recording sky brightness at various angles during the eclipse and for measuring atmospheric scattering of light. An AFCRL contractor, Southeastern College, Memphis, will measure temperatures of the solar chromosphere during the eclipse.

STABILITY OF CERTAIN trajectories IN THE FOUR-BODY PROBLEM

LYNN E. WOLAVER, Applied Mathematics Research Laboratory, ARL

Stability in politics, in economics and in other fields is much admired. It is no less so in outer space. The search for stable trajectories among the planets has been going on for centuries, starting with Lagrange in 1772 and continuing even today.

If one has only two massive bodies, their orbits are well known to be a portion of a conic section, e.g., they revolve in ellipses about their common center of mass. If now a third body is introduced, the solution has not been found in general. We have, however, some singular points which were found by Lagrange. (Reference 1.) He showed that, if the third body is placed at certain points, now called the Lagrange Libration Points, with zero relative velocity with respect to the two other rotating masses, then these three bodies would maintain their same relative orientation forever, to wit, the three bodies would lie at the vertices of an equilateral triangle. (Figure 1.)

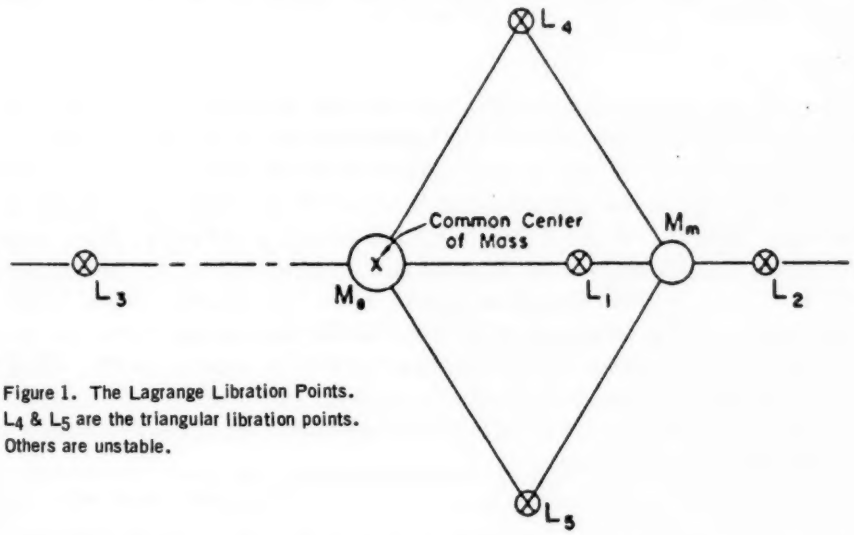


Figure 1. The Lagrange Libration Points. L_4 & L_5 are the triangular libration points. Others are unstable.

Furthermore, this triangle orientation (with minor restrictions) is a "stable" one in the sense that, if one of the bodies were "slightly"

disturbed from its original orientation, it would still tend to remain close to its assigned vertex and to approximate the triangle relationship. (Reference 2.) Examples of such trajectories are found in the solar system in the form of the Trojan Asteroids which are bodies moving about the libration point formed with the Sun and Jupiter. Recently, interest has been expressed in the investigation of these libration points in the Earth-Moon system. However, for this latter case, the Sun exerts a strong perturbing influence and one must consider the four bodies - the Sun, Earth, Moon and the particle. For this situation the results of Lagrange no longer apply, and one wonders if there are some orbits which are stable at or near these libration points.

In an oft-referenced but apparently seldom-read report, (Reference 3), Sehnal shows that the effect of the Sun is to produce unstable orbits for this case. However, in his short article in a not-too-accessible journal, he assumes that the Sun and Moon have the same angular rate about the Earth. This is highly unrealistic. He then proceeds to develop the variational equations (Reference 2) and to show that they give rise to unstable trajectories. Unfortunately, he incorrectly applies the technique; in fact his variational equations may be solved by the LaPlace Transform method to show that, contrary to his conclusion, these equations are stable for all initial conditions. Thus, we gain renewed interest in seeking stable trajectories in the four-body case.

Results of recent investigations by the Applied Mathematics Laboratory at Aerospace Research Laboratories have shown the rather striking effect of the initial orientation of the Sun-Earth-and Moon. If the particle is launched to arrive at the libration point at a time when the Sun-Earth-and Moon all lie along a straight line, then the orbit diverges as shown in Figure 2. However, if the particle is launched to arrive at the libration point when the Earth-Moon axis makes an angle of 135 degrees with the Earth-Sun axis, then the resultant trajectory exhibits all the properties of a stable orbit. (Figure 3.) It has been found stable for well over 400 days. In addition, the trajectory sensitivity to position and velocity errors at launch is greatly reduced for this case.

Current investigations using an approximate analytical solution have delineated initial conditions which give rise to an improvement on the trajectory shown in Figure 3.

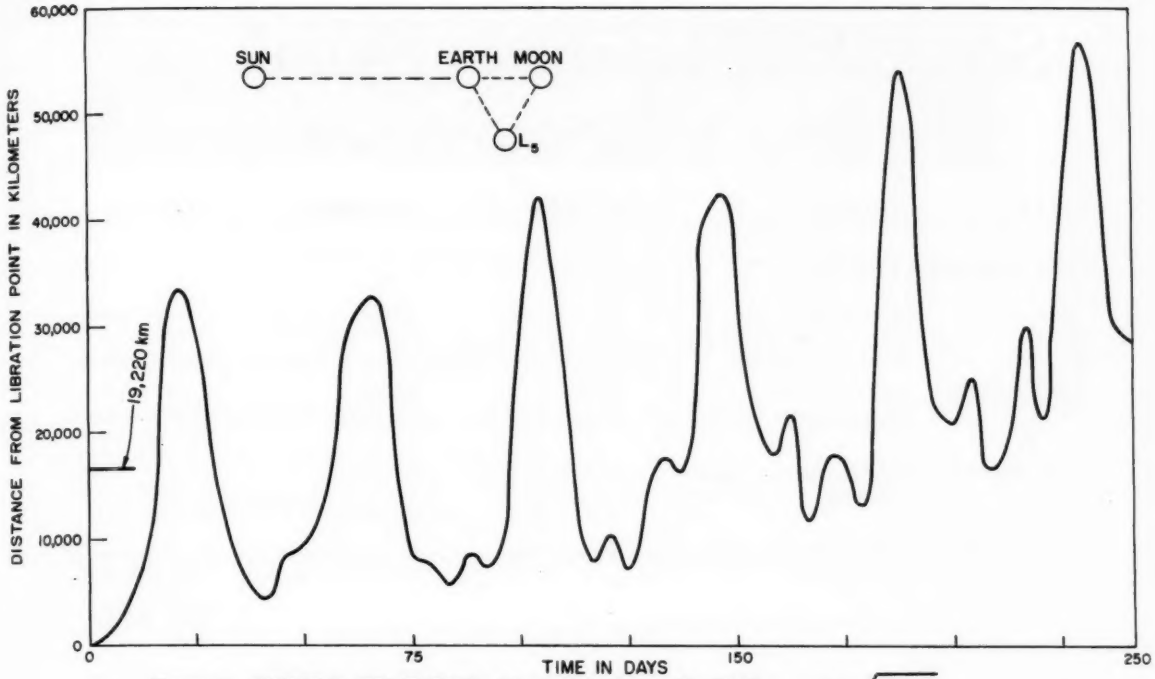


Figure 2. PARTICLE TRAJECTORY AS A FUNCTION OF TIME $r = \sqrt{x^2 + y^2}$

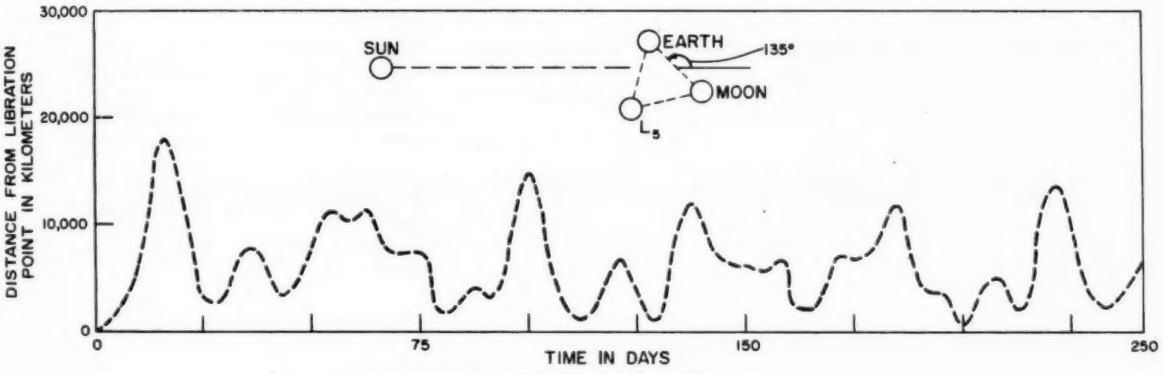


Figure 3. 135 DEGREE INITIAL ALIGNMENT

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1. Moulton, Forest Ray, An Introduction to Celestial Mechanics, MacMillan Company, New York, 1914, p.277.

2. Ibid., p.300.

3. Sehnal, L., "The Stability of the Libration Points L_4 and L_5 in the Earth-Moon System," Bull. Astron., Inst. Czechoslovakia, Vol. 11, No. 4, 1960, pp.130-131.

Schedule of Scientific Symposia

DATE	SUBJECT	PLACE	SPONSOR(S)	CONTACT
OAR SPONSORED SYMPOSIA				
5-9 Aug 1963	Structural Development in Inorganic Chemistry (Gordon Research Conference)	New Hampton, New Hampshire	AFOSR (Dir of Chemistry)	Mr. D. Elliott AFOSR (SRC) Wash. 25, DC
20-23 Aug 1963	Second International Pharmacological Meeting	Prague, Czechoslovakia	AFOSR (Dir of Life Sciences)	Dr. R. V. Brown AFOSR (SRLA) Wash. 25, DC
20-27 Aug 1963	XVI International Congress of Zoology	Washington, D. C.	AFOSR (Dir of Life Sciences), NAS/NRC	Dr. R. V. Brown AFOSR (SRLA) Wash. 25, DC
25-27 Aug 1963	High-Altitude Plastic Balloons	Boston, Mass.	AFCRL (Aerospace Instrumentation Lab)	Mr. T. Kelley AFCRL (CREB) L. G. Hanscom Field, Bedford, Mass.
8-10 Oct 1963	10th Annual Air Force Science & Engineering Symposium (SECRET)	Air Force Academy, Colorado Springs, Colorado	Office of Aerospace Research and Air Force Systems Command	Maj J. R. Shafer Hq OAR (RRON) Wash. 25, DC
Oct 1963	2nd Bagneres Conference on Lunar Topology	Bagneres-de-Bigorre and Pic-du-Midi Observatory, France	AFCRL (Terrestrial Sciences Lab); U of Manchester (England); Pic-du-Midi Obsv (France)	Mr. M. S. Hunt AFCRL (CRGG) L. G. Hanscom Field, Bedford, Mass.
28 Oct - 1 Nov 1963	International Symposium on Plasma Phenomena & Measurements	San Diego, Calif.	AFOSR (Dir of Engineering Sciences); Inst of Radio Engineers; AEC; NASA	Lt Col G. D. Colchagoff AFOSR (SRE) Wash. 25, DC
OTHER RDT&E SYMPOSIA OF INTEREST:				
14-16 Aug 1963	5th Biennial Gas Dynamics Symposium, "Physico-Chemical Diagnostics of Plasmas"	Northwestern Univ, Evanston, Ill.	Army Research Office (Durham)	Mr. J. J. Murray, U.S. Army Rsch Office, Box CM, Duke Station, Durham, N. C.
1-4 Sep 1963	International Conference on Oxygen in the Animal Organism	Bedford College London, England	Office of Naval Rsch; Int Union of Biochemists; Int Union of Physiological Sciences	Miss S. Kronheim Office of Naval Rsch Wash. 25, DC
4-7 Sep 1963	3rd International Conference on the Mossbauer Effect	Cornell Univ, Ithaca, NY	ARPA	

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